LEVEL II

AESD

TECHNICAL NOTE

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ACOUSTIC AREA ASSESSMENT

FEBRUARY 1975

C. W. SPOFFORD

ACOUSTIC ENVIRONMENTAL SUPPORT DETACHMENT

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This report describes the concept of "acoustic area assessment" as currently practiced at AESD. The product of an acoustic area assessment is a calibrated environmental and acoustic modeling capability relevant to a specific system in a specific geographic area. Within prescribed resource constraints, the capability combines the state-of-the-art in "modeling" the required acoustic parameters with the relevant

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environmental inputs required by the acoustic models. A "model" is taken in its most general sense to represent an interpolation and extrapolation from known results. Predictions based upon the models are accompanied by estimates of their accuracy to ensure that the true significance of inferred system performance can be estimated by the systems engineer.

Acoustic area assessment is described in the context of the LRAPP measurement program, in which case the results are documented in two types of reports: an area-wide summary report which assesses the acoustic implications of the measurements and modeling effort across a broad class of systems; and individual-system assessment reports which filter the data relevant to specific systems, and develop and evaluate the system-oriented acoustic and environmental models. While acoustic area assessment is an evolving process, "freezing" it in this document is intended to familiarize the systems-engineering community with the type of information available from an assessment, to convey to the measurement community some of the modeling needs, and to stimulate within the modeling community a dialogue leading to improvements in the process.

TABLE OF CONTENTS

A

LIST OF ILLUSTRATIONS

1.0 INTRODUCTION

The successful generation of meaningful acoustic inputs for system-performance analysis requires close communication between the acoustician (measurer or modeler) and the systems engineer (designer, deployer, or analyst). Figure 1-1 illustrates the basic relationships between the measurement, modeling, and systems-engineering communities. Models are used both to interpret the results of measurements in terms of acoustic implications for systems, and to ensure that the needs of the systems-engineering, design and analysis community are anticipated in future measurements. This report represents an attempt to strengthen the lines of communication by describing AESD's approach to "acoustic area assessment". The objective of an acoustic area assessment is to build a calibrated environmental acoustic predictive capability for the application to a particular system in a specific area. The systems engineer is then provided with predictions of the desired acoustic parameters based upon a mix of measurements and models and accompanied by measures of the prediction accuracy.

This capability has been generated as an integral part of the regional systems assessments of the LRAPP measurement programs. Within this context the formulation and calibration of acoustic and environmental models for an area build upon existing models and data bases, relying upon the LRAPP measurements both to fill critical gaps in the environmental model, and to reduce deficiencies in the acoustic models. By simultaneously addressing an area from the viewpoint of a number of existing and potential systems, considerable duplication of effort is avoided, and an area acoustic capability is developed for future systems assessments in addition to those carried out by LRAPP. Even without the benefit of a LRAPP exercise in a particular area, many of

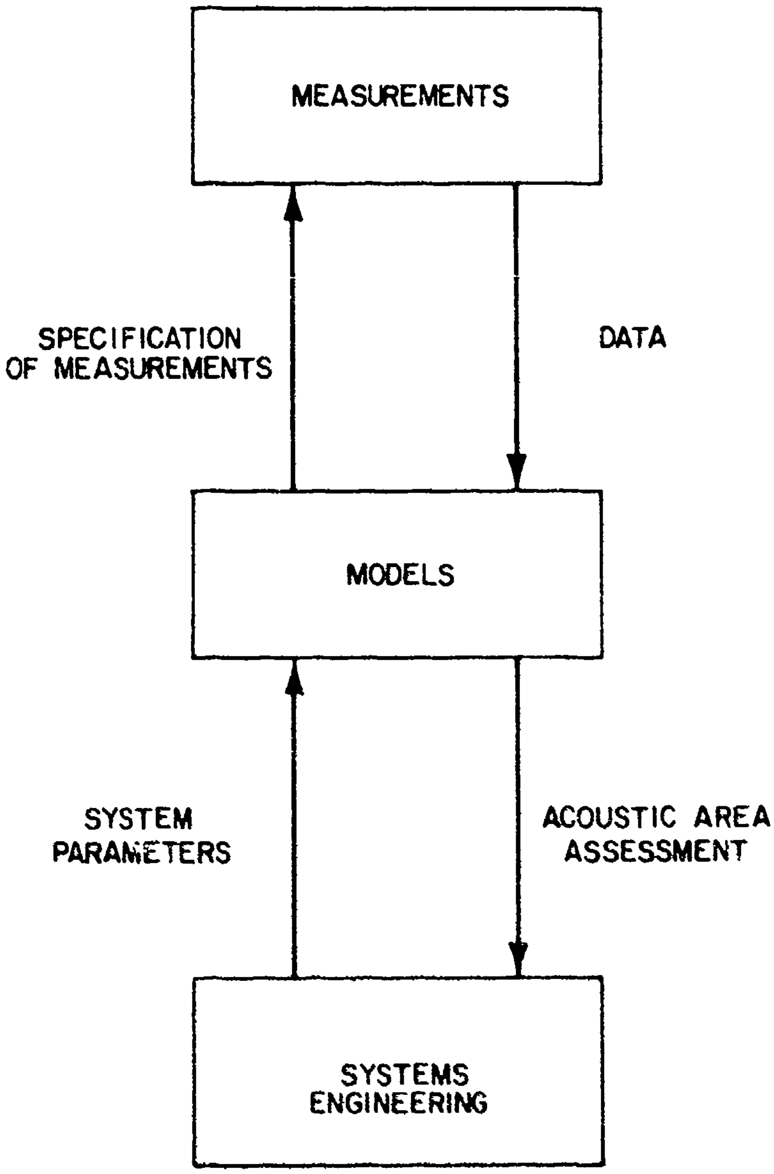

FIGURE 1-1. Information Flow Between Measurement, Modeling, and Systems Engineering Communities

the concepts described here can be applied to produce an acoustic area assessment with, presumably, larger uncertainties.

The approach, as described here, is somewhat idealized, and in practice has been considerably reduced in scope to conform to external time and resource constraints. The accuracy available solely from the present, fully automated models is insufficient for many applications, and a considerable effort must be devoted to developing system-oriented "models" in the more general sense described subsequently. For example, the unconstrained application of this approach to CHURCH ANCHOR and SQUARE DEAL assessments would require 6 months and 1 year, respectively, of four people given present modeling capabilities versus half that amount of time using the more advanced models which will be available in a year. While this long a delivery time may be unacceptable, one advantage is that given adequate time, more general as well as more automated models can be developed for future use.

It is hoped that this report will accomplish several objectives:

1. to acquaint the systems-engineering community with the type of information available from an acoustic area assessment;
2. to familiarize those involved in the planning of acoustic measurements with the capabilities and needs of these models, ensuring experimental design more attuned to the needs of the ultimate consumer;
3. by presenting these concepts as a first iteration, to stimulate an active dialogue within the environmental-acoustics community resulting in an improvement in the area-assessment process.

The reader should not be tempted to conclude that by describing the approach, AESD has reduced it to a sequence of

mechanical operations. While the converting of measured data and modeling insight into useful systems information is an advanced development program, it is closer to research in terms of the techniques employed. Any attempt to eliminate this type of analysis from the process would significantly degrade the value of the product to the Navy.

The following section describes more fully the techniques and products of an acoustic area assessment, first in the general context of a LRAPP exercise, and then in the more restricted application to a particular system. With this background, Section 3 relates area assessment with [redacted] the generation of acoustic parameters for a particular system study. Unless the desired quantities have been measured for the precise, required conditions, even the simplest application of measured results represents implicitely a "model". In this report, then modeling is taken in its most general sense as a means for extrapolating and interpolating from observed results. The objective is to provide the best estimate, as defined by the state-of-the-art and within the limitations of available resources, whether by a totally automated computer code based upon first principles, or by a simple extension of measurements.

The subsequent section describes the development of this modeling capability, an integral part of which is the quantitative calibration of absolute model accuracy. The uncertainty associated with a particular prediction is shown to stem from inaccuracies in the environmental as well as the acoustic models, and may also be made to reflect user-specified ranges in parameters such as source or receiver depths, frequency, etc.

A companion report will summarize the status of the acoustic and environmental models available to AESD and will be updated periodically to reflect changes in that

status. While one of AESD's missions is to synthesize Navy Standard Models, another is to provide those acoustic inputs needed by the systems-engineering community. The requirement for the best possible estimate may lead to the present Navy Standard Model, or it may suggest application of other models in the advanced development stage available at AESD, but not yet approved as Navy Standards. The careful exercise of these developmental models at AESD, by those involved in their development and familiar with their limitations, may produce the best results.

The discussion of these models, as well as the Navy Standard Models and the environmental models, is intended to acquaint the systems engineer and experimental designer with some of the additional capabilities which might be applicable to his problem. The specific model to be applied to answer a particular question should be selected by AESD and the investigator after joint consideration of the actual question being addressed. The independent translation by the investigator of his question ~~into a question~~ into a request for a number of model runs has been found to be a particularly inefficient, and in many cases futile, process.

2.0 RESULTS OF ACOUSTIC AREA ASSESSMENT

The ultimate product of an acoustic area assessment is a capability to provide relevant, calibrated acoustic inputs for a particular area. Much of the capability is passed on directly to the user in the form of a report describing the appropriate environmental factors for his system, and the corresponding acoustic models. If the model encompasses large computer codes, these will remain at AESD and be exercised upon request. In many cases, however, the sensitivity of the model to parameter changes can be described in the report, thereby avoiding extensive computer runs. In fewer cases an approximate, but sufficiently accurate quantitative model is included which the user can exercise himself within limits on the geometry and the environment provided by AESD.

2.1 Multiple-System Assessments

In the case of the LRAPP exercise, the individual system reports are preceded by a summary assessment report directed towards many possible systems, which provides a general discussion of the environmental and acoustic properties, and of the ability of our models to predict in this area. This report forms the basis for the individual system-assessment reports to be described in the following subsection. The purpose of this summary report is to act as the first filter on the experimental data and to make the first combination of the pre-exercise, or archival, data with the exercise results.

The summary report addresses, at a minimum, the following topics:

1. Available oceanographic models for the area including their resolution, calibration, and interface capabilities with appropriate acoustic

models. Oceanographic factors discussed are: four-dimensional sound-speed structure; bathymetry; bottom reflectivity; and wind-speed/wave-height information.

2. Additional environmental data from a wider geographic area pertinent to the ambient noise field within the area: ship densities; shipping routes; and distant bathymetric features, such as continental slopes.
3. Acoustic propagation and noise models relevant to the area, including: estimates of their accuracy from previous evaluations and comparisons with exercise data; their resolution and applicability to particular oceanographic features of the area; the relative efforts involved in their execution; and any particularly weak areas in the overall modeling capability.
4. A discussion of the relative influences of oceanographic features on classes of systems which may be differentiated in terms of their response to the environment.
5. A discussion of those environmental and acoustic factors which have been missed or undersampled in this exercise, leading to critical gaps or unacceptable uncertainties in the resulting area-assessment capability. This information should impact the design of future measurement programs.

The fourth item in this list considers only a limited class of systems in terms of their relative sensitivity. The specific discussions of the acoustic environment appropriate to these systems, and others, are reserved for the subsequent system-oriented assessment reports.

2.2 Individual-System Assessment

The first step in generating an individual-system assessment report is to distill from the multiple-system report the information relevant to a single system. This information is then augmented by all available data and leads to an absolute measure of system sensitivity to the acoustic environment rather than the relative sensitivity discussed in the multiple-system assessment. It is in this report that the specific system-oriented environmental and acoustic models are formulated and calibrated. The degree of interaction between the acoustician and systems engineer is multiplied many-fold in this phase over that required in the summary-assessment. At this point the systems engineer must define how his system (or at least his model for the system) works, in sufficient detail to permit the acoustician to formulate the meaningful acoustics questions. This is an iterative process in which both participants exchange relevant information and understanding.

The report represents a collaborative effort and provides the systems engineer with the capability to perform at least some of his sensitivity studies without exercising expensive computer codes. The information provided to the acoustician should highlight weaknesses in both experimental design and his acoustic-modeling capability. The specific contents of a system report are not enumerated here since they vary substantially from system to system.

3.0 ACOUSTIC PARAMETERS FOR SYSTEM PERFORMANCE ESTIMATION

The competition for limited resources between a number of existing and proposed acoustic systems in an area requires the ability to quantitatively assess system performance against present and projected threats. With the advent of automatic detectors, the detection process is a defined, modelable process, given the input signal-to-noise ratio. Models have been developed for these, as well as the less deterministic detectors, which when married with higher level engagement models permit an assessment of system performance. A detailed defense of the need for such models is not attempted here; but clearly one cannot measure the performance of a non-existent system against a projected threat. Even for existing, deployed systems, the cost of measuring system performance with calibrated simulation threats is prohibitive. While the systems engineer defines the threat and the processing techniques, the properties of the received signal and the masking background, or noise, lie in the domain of the acoustician. The generation of these acoustic inputs is the subject of this section.

Figure 3-1 illustrates the relationship between performance prediction and the generation of acoustic parameters. The desired acoustic parameter, Y_J, may be transmission loss, noise, or any of a number of properties and depends on parameters, y_i, including both geometric factors, (range, depth, etc.) and the environment. In the very unlikely event that the precise desired parameter has been measured for the precise geometry and environment specified, the measured value, Y_M, is provided. If this route is not available, the parameter must be modeled.

The modeled value represents the best estimate obtainable within the constraints of available resources and the required accuracy of the estimate as specified by the user.

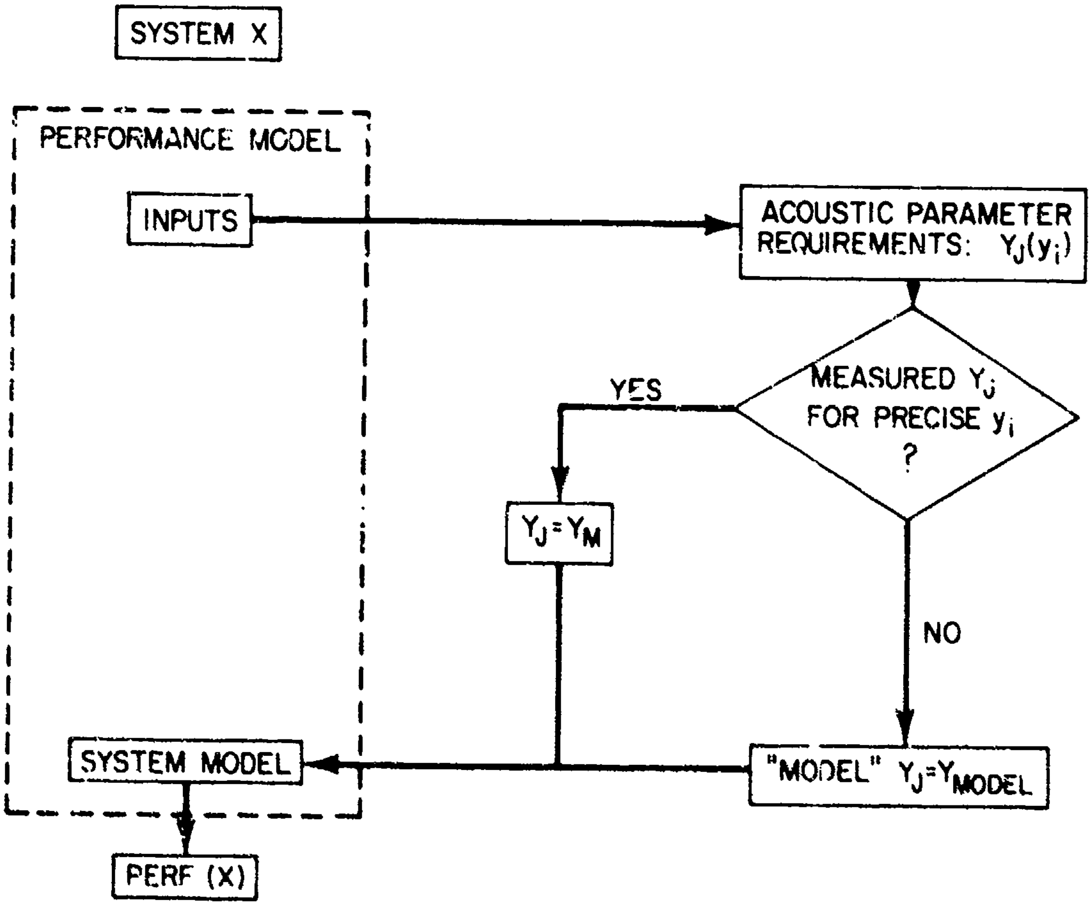

FIGURE 3-1. Relationship Between Performance, Prediction and Generation of Acoustic Parameters

Wherever possible and cost-effective, fully automated computer codes will be employed. The advanced development effort at AESD has as its major objective the synthesis of models which are fully automated and sufficiently accurate for a wide spectrum of applications. Where computer codes are not employed, the model used is documented so that the results provided are repeatable and may be consistently expanded upon at a later date.

In the latter cases the "model" may vary from a direct interpolation in data to the use of the computer-code model to determine only relative differences which are then added to the measured data. In all events some measure of the accuracy of the modeled value is provided as well as its sensitivity to parameter variation. This sensitivity analysis can frequently be used to avoid additional model runs, reducing the overall cost and permitting the application of more powerful models to fewer cases.

Figure 3-2 illustrates the modeling process and reemphasizes the required interaction between the systems engineer and the acoustician. Assuming that the quantity has not been measured under the precise specified conditions, the procedure involves the selection of an appropriate computer code as a candidate predictor. This selection combines the accumulated prior knowledge of model accuracy with the evaluation associated with the LRAPP exercise, if available, and with the system sensitivity and accuracy requirements provided by the systems engineer. From the exercise and archival data banks, measurements (Y_J) which are "close" to the desired quantity in terms of geometry and environment are selected along with their associated conditions (y_m).

The selected code is executed under these conditions and the predicted values are compared with the measured to assess model accuracy. The decision on the adequacy of

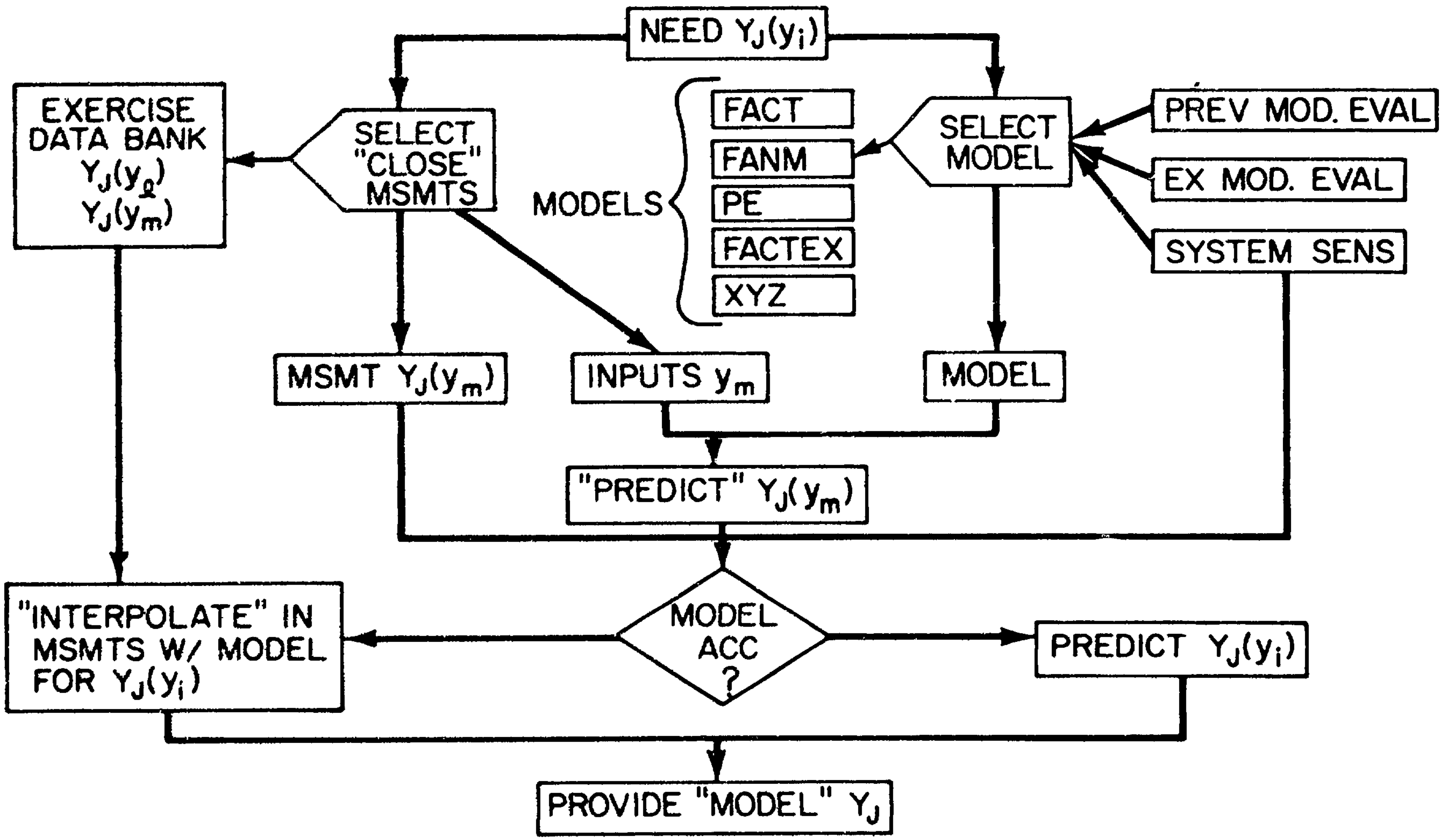

FIGURE 3-2. "Modeling" Acoustic Parameters

the model must be made by the systems engineer in conjunction with the acoustician. If the model accuracy is unacceptable, a branch not indicated in the figure considers the selection of a more powerful model which may require a reduction by the systems engineer in the number of runs requested. The process is repeated until either an acceptable model is found (at which time it is exercised with the desired conditions (y_i) to provide a prediction), or it is determined that no computer code can provide the desired results within the resource constraints. At this point the type of interpolation described above, based upon the models and data, is performed to provide the prediction. Since the interpolation process is likely to be more costly than executing the computer codes, the systems analyst may again be required to reduce the number of estimates required. This iterative, inter-active process is required to ensure that model predictions have an accuracy satisfactory to the systems engineer.

4.0 ACOUSTIC AREA ASSESSMENT

The development of this predictive capability is the objective of acoustic area assessment. The assessment process is described in this section in the context of a LRAPP exercise and consists of four basic phases:

1. The pre-exercise phase which leads to certain requirements on the exercise program;
2. The post-exercise phase in which an intensive analysis of the experimental data leads to area-wide environmental and acoustic models;
3. The evaluation phase which calibrates both models;
4. The prediction phase as already described.

In the absence of a LRAPP exercise, other available archival data are examined, and phases 2 through 4 are executed. The systems emphasis in these phases shifts from multiple to individual systems as the process progresses. The summary-assessment report stops at phase 3, while the individual-assessment report involves phases 2 through 4. Figure 4-1 expands upon this concept and serves as the basis for the discussion in the following subsections.

4.1 Phase 1 - Pre-Exercise

Given that a set of environmental-acoustic measurements will be made in a particular area, the first step is to assess the adequacy of existing environmental and acoustic models for that area with respect to the needs of present and envisioned acoustic systems. In order to perform an acoustic area assessment for a number of systems, a determination must be made of first, those environmental factors which critically influence each system's performance, and second, what additional measurements are required to provide an environmental data base and an acoustic model calibration of sufficient accuracy to anticipate the systems requirements.

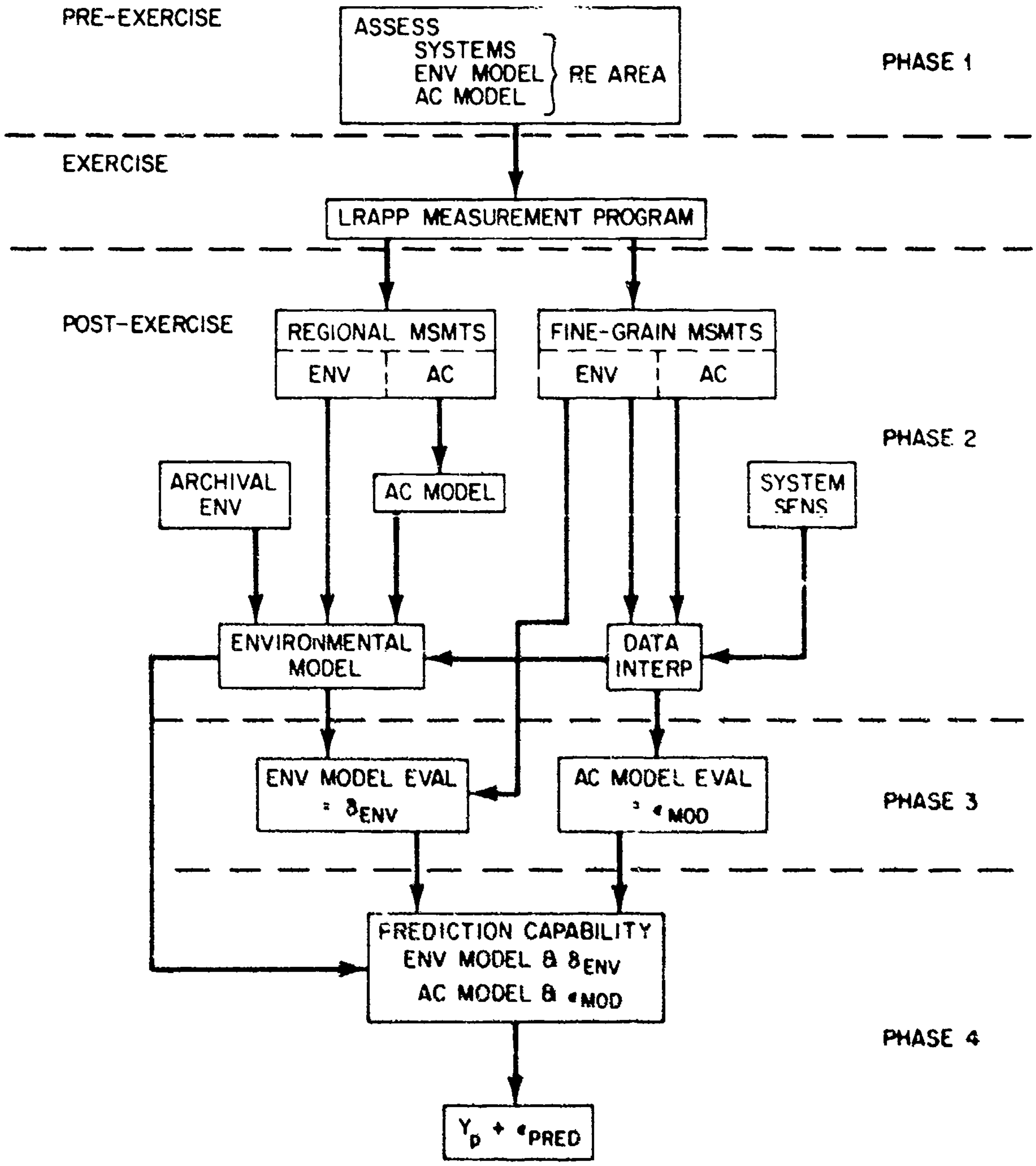

FIGURE 4-1. Acoustic Area Assessment

In this process selected models are exercised with inputs varying within the environmental uncertainties and in geometries associated with different classes of systems. Unusual oceanographic features are identified to determine environmental-measurement requirements, and to alert the experimental designer to unusual regimes which may require extraordinary measurement procedures.

The end-result of this process is the generation of requirements for two classes of measurements. Regional measurements are intended to address gaps in the environmental models for the area. Some may be direct oceanographic measurements (sound-speed profiles, etc.), others direct measurements of other environmental factors (ship densities, etc.), and still others may be acoustic measurements from which environmental parameters are inferred. For example, while area-wide detailed reflectivity measurements such as those acquired by NOO and NADC may not be feasible, gross reflectivity samples may be obtainable by the analysis of a number of shots on a number of different sensors, considerably expanding the bottom-reflectivity data-base in this area.

The second class of measurements consists of at most a few sets of high-resolution (fine-grain) environmental and acoustic measurements. These measurements form the basis for subsequent model evaluation. The hope is to make them with sufficient accuracy in geometry, environmental sampling and data reduction techniques that experimental errors are negligible, thus permitting the extraction of the actual model error. These measurements focus on critical, untested aspects of the acoustic models. The concurrent oceanographic measurements are required by the acoustic models and are also used to calibrate the area-wide environmental models.

4.2 Phase 2 - Model Development

The first post-exercise phase consists of a period of intensive data analysis and interpretation leading to the assembling of the environmental and acoustic models for the area. The fine-grain acoustic data are examined, using models as tools, for features indicating physical mechanisms which are either missing from or mistreated in the models, and which may have significant implications for particular systems. The appropriate acoustic model for a system may be highly dependent upon this analysis. The measurements selected for detailed model-evaluation studies also are determined at this stage.

In this phase AESD requires a limited in-house or local data-processing capability to analyze selected segments of data in non-standard ways (digital arrival structure, very narrow-band analysis, cross-correlation between hydrophones, etc.). The precise data to be analyzed cannot be specified until the standard data are examined, and the processing techniques must be adapted to each situation as the analysis progresses. Hence it is impossible to include the processing of these data sets in the routine data reduction.

The environmental information obtained through this analysis is combined with the area-wide measurements and the archival environmental data to form the area-wide environmental models. In addition to the types of environmental data referred to earlier, it may be possible to simplify the dependence of some systems to a processed subset of the overall environment, such as mixed-layer depth, surface sound-speed, or depth excess. These simpler environmental models frequently provide new insight into the sensitivity of system performance to environmental parameters.

4.3 Phase 3 - Model Evaluation

In the model evaluation phase the accuracy and resolution of both the acoustic and environmental models for the area are estimated. The accuracies of both models are required to estimate the accuracy or variability of a prediction. In particular, if we take as an example the modeling of transmission loss, a prediction may have errors associated with the estimates of the environment as well as the fundamental accuracy of the acoustic model.

4.3.1 Environmental Model Evaluation

The environmental model evaluation compares estimates of the environment obtained from the four-dimensional (position and time) fields and compares them with the detailed fine-grain measurements collected in the exercise. Differences may be attributed to combinations of field resolution, field interpolation algorithms and, since all current environmental models assume repeatability from year to year, the variations in the environment at one position and time of year to the same position and time in a different year. These observed differences indicate possible spreads between predicted and actual environments and produce through the acoustic model a corresponding variation in the prediction.

4.3.2 Acoustic Model Evaluation

The accuracy of acoustic models has advanced to the point that, in evaluating acoustic model error, measurement uncertainties must be considered. If, in the example of transmission loss, we define the model error, ϵ_{MOD}, to be the difference between predicted (TL_p) and actual (TL) transmission loss under identical conditions, then

$$\varepsilon_{MOD}(X) = TL_P(X)-TL(X) \tag{4-1}$$

where X is a multi-dimensional variable upon which transmission loss depends. In particular

$$X = (ENV,Z) \tag{4-2}$$

where ENV represents all environmental influences, and Z represents the source-receiver geometry within the environment. Any averaging or integration contained in the measurement (i.e. time averages in CW data, or third-octave processing in shot data) must, of course, be simulated in the model.

Letting the subscript M denote a measured or reported value, then we may rewrite Equation 4-1, by adding and subtracting similar terms, to obtain

$$\varepsilon_{MOD}(X) = [TL_P(X)-TL_P(X_M)]+[TL_P(X_M)-TL_M(X)] + [TL_M(X)-TL(X)] \tag{4-3}$$

or

$$\varepsilon_{MOD}(X) = \varepsilon_{IN}(X,X_M)+\varepsilon_{OB}(X,X_M)+\varepsilon_{PS}(X) \tag{4-4}$$

The model error, then, consists of three (not independent) terms. The second term, ε_{OB}, is the difference between the predicted and measured values and has frequently been confused with model error. For models of low accuracy it dominates the other two terms and may reasonably approximate ε_{MOD}. The first term, ε_{IN}, reflects the difference between the predicted value for the actual geometry and

environment, and the predicted value for the reported geometry and environment (denoted by X_M). Hence it reflects model sensitivity to errors in inputs. The largest such errors in current measurements are associated with source ranges and depths. The third term, ε_{PS}, reflects the difference between the actual and measured values of transmission loss. Errors here may be associated with source levels (especially for shots), hydrophone sensitivities, and analysis techniques.

The objective in model evaluation is to determine the probability of a particular value of model error, given the set of observed errors, that is $P(\varepsilon_{MOD}|\varepsilon_{OB})$. This requires estimates, from those involved in the measurement, of uncertainties in all measured and reported values. Since ε_{IN}, ε_{MOD}, and ε_{PS} are not independent, the approaches used in the construction of the distribution of ε_{MOD} are sufficiently complex to be beyond the scope of this report. The application of this technique to comparisons of PARKA Data and predictions using AESD's most powerful transmission-loss model, the Parabolic Equation Model, indicated that errors associated with the measurement process, in particular source range and source level, were competitive with the apparent model error for RR and RSR paths. Hence the observed error consists of nearly equal parts measurement and model error.

4.3.3 Experimental Considerations

These considerations have several implications for experiment design. In the presence of experimental error, even a perfect model will yield an observed error (that is, ε_{OB} will not be identically zero). Alternatively, even if the predicted and measured values agreed precisely ($\varepsilon_{OB}\equiv 0$),

the estimate of model error will be limited by the remaining uncertainties in ε_{IN} and ε_{PS}. That is $P(\varepsilon_{MOD}|\varepsilon_{OB}\equiv 0)$ will have a distribution driven by measurement errors. If the distribution suggests a model error which is unacceptable for the application of this model to a particular system question, then this experiment cannot be used to decide whether the model has sufficient accuracy. Note that this inference can be made prior to the experiment if a priori estimates of geometry, environment, and processing errors are supplied by the experimentalist. This type of pre-exercise planning with the aid of models is critical to ensuring the usefulness of measured results in assessing model accuracy. A particularly inefficient use of modeling resources, which serves no useful purpose, is the pre-exercise prediction of results for all planned measurements.

4.4 Prediction Accuracy

Given evaluated acoustic and oceanographic models, it is now possible to provide acoustic predictions with measures of the uncertainties associated with both the environmental and acoustic models. If the error in the prediction, ε_{PRED} is defined by

$$\varepsilon_{PRED} = TL_P(X_P)-TL(X) \qquad (4\text{-}4)$$

where the error in input is solely environmental,

$$X_P = (ENV_P, Z) \qquad (4\text{-}5)$$

then

$$\begin{aligned}\varepsilon_{PRED} &= [TL_P(X_P)-TL_P(X)]+[TL_P(X)-TL(X)] \\ &= \varepsilon_{ENV}(X_P, X)+\varepsilon_{MOD}(X) \qquad (4\text{-}6)\end{aligned}$$

and the sensitivity of the prediction to the environmental uncertainty, ε_{ENV}, may be combined with the model error to obtain the prediction error.* An example of a statement of prediction error might be that the predicted losses have errors of less than 3 dB 90 per cent of the time.

This procedure can be extended to include in the prediction uncertainty the variations associated with specified ranges in geometric factors (Z) such as source depth. The above techniques can also be applied beyond this example of transmission loss to other acoustic parameters such as convergence-zone levels and ranges, or the fraction of range with loss less than a certain value, or ambient noise level, or signal-to-noise ratio. While the uncertainties associated with loss versus range may appear substantial, the corresponding uncertainty in detection-related quantities may be much less. In some instances it may be cost effective to apply the techniques directly to quanties like probability of detection by functionally relating them to the acoustic variables.

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* Frequently, environmental models are based upon measurements themselves, perhaps in the same month and location as the fine-grain measurement, but in a different year. Since neither environment is "in error" in this case, ε_{ENV} may more accurately be considered as a measure of the variation in conditions expected at this location from year to year.

5.0 SUMMARY

This report reflects a program at AESD to coordinate the process of acoustic area assessment from the pre-exercise phase through the delivery of acoustic parameters relevant to a specific system. The utility of the results of future measurement programs in the assessment process depends critically upon the extent to which the experimental design addresses those model deficiencies which have the highest impact on the ability to predict system performance. A high degree of coordination and communication is required between the measuring, modeling and systems-engineering communities.

While the acoustic area assessment process functions best in conjunction with a measurement program, the capability can be developed for any area and system. By this process the systems engineer is provided with state-of-the-art estimates within the usual resource constraints. Included with these acoustic parameters are estimates of their accuracy, permitting the systems engineer to estimate the true significance of predicted differences in system performance.

LIST OF ACRONYMS

ABBREVIATION	DEFINITION
AESD	Acoustic Environmental Support Detachment
CW	Continuous Wave
LRAPP	Long Range Acoustic Propagation Project
NADC	Naval Air Development Center
NOO	Naval Oceanographic Office
RR	Refracted-Refracted
RSR	Refracted (at depth) - Surface Reflected

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2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

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Unavailable	Beam, J. P., et al.	LONG-RANGE ACOUSTIC PROPAGATION LOSS MEASUREMENTS OF PROJECT TRANSLANT I IN THE ATLANTIC OCEAN EAST OF BERMUDA	Naval Underwater Systems Center	740612	ADC001521	U
Unavailable	Cornyn, J. J., et al.	AMBIENT-NOISE PREDICTION. VOLUME 2. MODEL EVALUATION WITH IOMEDEX DATA	Naval Research Laboratory	740701	AD0530983	U
Unavailable	Unavailable	COHERENCE OF HARMONICALLY RELATED CW SIGNALS	Naval Underwater Systems Center	740722	ADB181912	U
Unavailable	Banchero, L. A., et al.	IOMEDEX SOUND VELOCITY ANALYSIS AND ENVIRONMENTAL DATA SUMMARY	Naval Oceanographic Office	740801	ADC000419	U
3810	Unavailable	CONSTRUCTION AND CALIBRATION OF USRD TYPE F58 VIBROSEIS MONITORING HYDROPHONES SERIALS 1 THROUGH 7	Naval Research Laboratory	741002	ND	U
ARL-TM-73-11; ARL-TM-73-12	Ellis, G. E., et al.	ARL PRELIMINARY DATA ANALYSIS FROM ACODAC SYSTEM; ANALYSIS OF THE BLAKE TEST ACODAC DATA	University of Texas, Applied Research Laboratories	741015	ADA001738; ND	U
Unavailable	Mitchell, S. K., et al.	QUALITY CONTROL ANALYSIS OF SUS PROCESSING FROM ACODAC DATA	University of Texas, Applied Research Laboratories	741015	ADB000283	U
Unavailable	Unavailable	MEDEX PROCESSING SYSTEM. VOLUME II. SOFTWARE	Bunker-Ramo Corp. Electronic Systems Division	741021	ADB000363	U
Unavailable	Spofford, C. W.	FACT MODEL. VOLUME I	Maury Center for Ocean Science	741101	ADA078581	U
Unavailable	Bucca, P. J., et al.	SOUND VELOCITY STRUCTURE OF THE LABRADOR SEA, IRMINGER SEA, AND BAFFIN BAY DURING THE NORLANT-72 EXERCISE	Naval Oceanographic Office	741101	ADC000461	U
Unavailable	Anderson, V. C.	VERTICAL DIRECTIONALITY OF NOISE AND SIGNAL TRANSMISSIONS DURING OPERATION CHURCH ANCHOR	Scripps Institution of Oceanography Marine Physical Laboratory	741115	ADA011110	U
Unavailable	Baker, C. L., et al.	FACT MODEL. VOLUME II	Office of Naval Research	741201	ADA078539	U
ARL-TR-74-53	Anderson, A. L.	CHURCH ANCHOR EXPLOSIVE SOURCE (SUS) PROPAGATION MEASUREMENTS (U)	University of Texas, Applied Research Laboratories	741201	ADC002497; ND	U
MCR106	Cherkis, N. Z., et al.	THE NEAT 2 EXPERIMENT VOL 1 (U)	Maury Center for Ocean Science	741201	NS; ND	U
MCR107	Cherkis, N. Z., et al.	THE NEAT 2 EXPERIMENT VOL 2 - APPENDICES (U)	Maury Center for Ocean Science	741201	NS; ND	U
Unavailable	Mahler, J., et al.	INTERIM SHIPPING DISTRIBUTION	Tetra, Tech, BB&N, & PSI	741217	ND	U
75-9M7-VERAY-R1	Jones, C. H.	LRAPP VERTICAL ARRAY- PHASE IV	Westinghouse Electric Corp.	750113	ADA008427; ND	U
AESD-TN-75-01	Spofford, C. W.	ACOUSTIC AREA ASSESSMENT	Office of Naval Research	750201	ADA090109; ND	U